10/538194

JC17 Rec'd PCT/PTO 09 JUN 2005

Express Mail Label No. EV645914486US

SUBSTITUTE SPECIFICATION

[0001] INTAKE ASSEMBLY FOR SELF-PROPELLED POOL CLEANER

[0002] FIELD OF THE INVENTION

[0003] The invention relates to automatic submerged, self-propelled pool cleaners and, in particular, that type of pool cleaner incorporating a rotor or impeller to drive the self-propelling mechanism, as distinct from those pool cleaners relying upon differential water hammer for propulsion (oscillation-type).

[0004] BACKGROUND

[0005] Submerged, self-propelled pool cleaners typically comprise the pool cleaner device connected to a pool filter and pump via a flexible hose and pump/filter pipe infrastructure. The attached pump provides a negative static pressure drawing water through the pool cleaner so that the water may be filtered to remove various debris and, in the case of a saltwater pool, to pass over an electrode for dissociating chlorine from the salt and so disinfect the water.

[0006] Submerged self-propelled pool cleaners use the negative static pressure to drive the device around the pool so that debris and material adhering to the floor and walls of the pool may be drawn in through the device and subsequently filtered from the pool water.

[0007] The following provides a general summary of self-propelled pool cleaners.

[0008] The invention of US 4,536, 908, the contents of which are incorporated herein by reference, is of the turbine type. US 4,536, 908 discloses a suction cleaner for a swimming pool that is supported on a bogie or truck assembly with inclined supporting feet. The bogie assembly is mechanically rocked by means of a turbine through which water is pulled by suction to cause the cleaner to move.

[0009] In order to change the direction of the cleaner, a second turbine drives a hose connection at the top of the cleaner in opposite directions with long periods of dwell in between. The device is continuously driven in the forward or turning directions and is driven and steered by three turbines and three gearboxes.

[0010] Another pool cleaner of the turbine type is disclosed in US 4,939, 806, the contents of which are incorporated herein by reference. The disclosed invention is a cleaner having a head mounted on wheels. There is a suction passage and a propeller which is driven by the turbine and which propels the head. A rudder, which is oscillated via a gear train driven by the turbine, is used to vary the direction of movement of the head.

[0011] A further turbine pool cleaner is disclosed in US 5,099, 535, the contents of which are enclosed herein by reference.

[0012] In this device, a cleaner for a submerged surface comprises a body that defines a suction passage and pressure passage. The suction passage extends between an inlet and outlet in the body and is connectable to the inlet of a filtration system by flexible hose. A second hose connects the inlet on the device to an outlet of the system. Water flowing under pressure to the inlet drives a turbine which in turn drives hind wheels to displace the apparatus over the surface while debris or the like is sucked up through the suction passage and out through the hose that is attached to the filtration system. The suction and return hoses are those of the flexible kind typically used in swimming pool cleaning systems.

[0013] An oscillating version of pool cleaner is disclosed in US 4,208, 752, the contents of which are incorporated herein by reference. The invention of US 4,208, 752 discloses an apparatus for cleaning swimming pools in a stepwise movement over the pool walls comprises a balanced operating head having an inlet and an outlet, the outlet adapted to be swivelably connected to a longitudinally resilient and flexible suction hose. The inlet axis is inclined at an angle to that of the outlet. A passage extends through the head from inlet to outlet, and an oscillator valve in the head is adapted to alternately open and

close said passage. A baffle plate is disposed in the head between the inlet and valve to form a restricted suction connection between inlet and outlet around the valve when the passage is closed. The flow of water causes the valve to oscillate between its two terminal positions. In one position, the flow is full and direct through the opening and passage to the outlet. In the other position of the valve, there is a maximum reduction in liquid flow through the head. This results in an intermittent cut off flow through the head as the valve oscillates between its terminal positions, and this in turn causes pulsation which result in longitudinal contractions and relaxations in the longitudinally resilient suction pipe from the head to the outlet from the swimming pool to its filter unit. In consequence of these contractions and relaxations and a simultaneous reduction and increase of the force applied to hold the cleaning head disc against the surface to be cleaned, a step by step movement of the head takes place over the surface to be cleaned.

[0014] A second oscillating pool cleaner is disclosed in US 4,807, 318, the contents of which are incorporated herein by reference. An automatic pool cleaner is disclosed which also operates on the interruption of an induced flow of water through the cleaner. The interruption in the flow of water drawn through the pool cleaner is used to provide a propulsive force to cause the cleaner to move over submerged pool surfaces. The control of the interruption is effected through a tubular axially resilient diaphragm one end of which is closed and adapted to hold normally closed a passage from the head of the pool cleaner to the usual form of flexible hose connecting the pool cleaner to the filtration unit. The flow of water through the pool cleaner causes a suction in a passageway greater than that in a connection, the result being that a spring and diaphragm force the closure of the passageway. The intermittent interruption of flow through the passageway and hose, and the simultaneous release of the force holding the cleaner and disc against the submerged surface causes the cleaner to move in a stepwise manner over the surface to be cleaned.

[0015] Both the turbine and oscillation type pool cleaner requires the ingress of water flow to be at high speed. In the case of the turbine, the energy imparted to the turbine is drawn from the kinetic energy of the velocity head of

the inflowing water, thus the faster the flow of water, the greater the energy imparted to the turbine and consequently the pool cleaner will move more effectively. The oscillation type of pool cleaner depends upon the differential of momentum caused by a water hammer event being as a direct result of the mass flow of the water. Being directly proportional to velocity of the water, consequently effective movement is also dependent upon the velocity head of the inlet water flow.

[0016] This need for a high velocity head for effective movement is also a considerable limitation on the ability of the pool cleaners to process large objects.

[0017] On the basis that a pool pump and filter will be somewhat standard, for instance, for a 50,000 litre pool, a one horse power pump is typical, then the static negative pressure imparted by the pump will be the same irrespective of the type of pool cleaner. To increase the velocity head of the inlet water flow and so ensure the effective functioning of the pool cleaner, it is necessary to reduce the size of the inlet orifice and maximize velocity head through the venturi effect. It follows that a reduction in the size of the inlet orifice will restrict the size of object that can be collected by the pool cleaner. Neither the turbine nor the oscillation type of pool cleaner presents a particular advantage in collecting large objects.

[0018] SUMMARY

[0019] It is therefore an object of the present invention to provide a pool cleaner that is not reliant upon a high velocity head of inlet water flow in order to function effectively.

[0020] Therefore, the invention provides a rotor assembly for a self propelling pool cleaner including a housing having a water inlet orifice and a water outlet orifice, a rotor within the housing including a plurality of vanes defining a plurality of spaces between adjacent vanes each vane having pressure sealing means forming a pressure seal between adjacent spacers when said pressure sealing means is in contact with an internal wall of the housing wherein a negative static water pressure applied at the outlet orifice leads to a

differential water pressure between two adjacent spaces causing rotation of the rotor;

wherein the vanes include stiffening means to support the vanes against the differential pressure; and

wherein the stiffening means includes a discrete stiffening member for each of said vanes;

wherein the stiffening members include at least one suction channel providing fluid communication between adjacent spaces and a deformation face adjacent to the relevant vane such that on application of the differential pressure the vane is drawn towards the at least one suction channel so as to contact the deformation face and so deform the vane and seal the suction channel against further fluid communication wherein said deformed shape of said vane imparts a greater flexural stiffness to the vane as compared to the undeformed shape.

[0021] As defined in Engineering Hydraulics by Rouse (Wylie 1950), an impulse turbine is defined as a system which converts velocity head to mechanical energy through impacting a rotor or impeller with a high velocity jet"... thereby giving up its kinetic energy to the..."rotor (page 939). The turbine type pool cleaner functions in precisely the same way and is correctly identified as a turbine in that mechanical energy to propel the cleaner is derived from the kinetic energy of the high velocity inlet water flow.

[0022] The present invention differs markedly in that it is analogous to a hydraulic motor.

[0023] The present invention does not rely upon a high velocity head from the inlet but instead creates a pressure differential between adjacent spaces within the housing of the rotor assembly. The differential pressure applies a force against the inlet side of the vane dividing the spaces having the differential pressure driving the rotor in a direction towards the outlet orifice. The mechanical energy required to drive the pool cleaner is imparted by the work done by the pressure differential and so is dependent upon the force applied and consequently the negative static pressure applied by the pool pump and not the kinetic energy derived from the velocity head of the inlet water flow. This system

is inherently more efficient in that velocity head can be reduced by shock losses as the inlet water flow enters the chamber and also losses in impacting the vanes of the turbine. By deriving mechanical energy from the work done by the pressure differential, the only practical losses are those of windage of the rotor, which are present in the turbine system in any case.

[0024] Therefore, the present invention by adopting a principle similar to a hydraulic motor is inherently more efficient and so displays a distinct advantage over the turbine pool cleaners of the prior art.

[0025] In essence the invention requires only a rotor having a pressure sealing means such that the static pressure developed by the pool pump drives the rotor rather than the high velocity water jet which is needed for a turbine type pool cleaner. To this end being driven by the static pressure permits the inlet orifice to be as large as possible and so accept larger objects to by passed through the rotor assembly.

[0026] The key advantage, however, of the present invention over the prior art is that as there is no dependence upon the velocity head, there is no need to generate a high velocity jet entering the housing and so the inlet orifice is not limited in size and, in fact, it is preferable that a much larger inlet orifice is used not only to receive larger objects, but also to maximize the pressure differential by reducing the velocity head.

[0027] Because the rotor is driven by an applied force proportional to the negative static pressure, the vanes must be stiff enough, or supported sufficiently, to resist the load and not buckle or collapse under the applied load. Therefore, the vanes may be made of metal or plastic and sized so as to resist the applied loading.

[0028] Having a relatively stiff vane, it is necessary to seal between the vane and the internal wall of the housing but may be flexible enough to buckle and enable the passage of large objects.

[0029] The vane may be constructed from a flexible material and supported by a more rigid member and so combining the effects of the pressure sealing means with sufficient rigidity to resist the applied force. It must be recognised

that in such an arrangement, a balance in the selection of materials must be made so as to be sufficiently flexible to act as a seal but stiff enough so that any unsupported portion of the flexible vane may still resist the applied force. The person skilled in the art will recognise that such a selection, as well as dimensioning the rigid element, will be an iterative process dependent upon the magnitude of the pressure differential.

[0030] So as to enhance the range of applicability of a pool cleaner, as well as making savings on material costs and customer perceptions, it is commercially advantageous to minimise the size of the pool cleaner. It follows therefore that reducing the size of the rotor assembly will also be advantageous. With this in mind, applying the present invention to the problem of reducing the rotor assembly, it will be recognised that the pressure differential is driving the rotor, and that pressure differential is directed from the inlet orifice to the outlet orifice.

[0031] On the return portion of the rotation of the rotor, the relevant spaces will not experience a pressure differential and, therefore, not experience the associated applied force. Therefore, the housing may be reduced in size on the return portion from the outlet to the inlet orifice. By reducing the size of the housing on this return portion, it is possible to collapse the vanes in a resilient flattening manner so that on the drive portion between the inlet and outlet, the vanes recover so as to resist the applied forces. Thus, in a preferred embodiment of the invention, the vanes may be capable of a directional stiffness such that they may be stiff enough to resist the applied force but may be collapsed, in a resilient manner when contacted by collapsing means on the return portion of the chamber.

[0032] Preferably, the directional stiffness may be provided by the" tape measure" effect whereby the material of the vane may be metal or plastic in a curved shape whereby the applied force acts on the concave face of the curve. As with a tape measure when a force is applied on the concave face, the curved shape increases the moment of inertia of the tape and provides a higher degree of stiffness. However, a force applied on the convex side of the tape leads to the tape measure flattening. Consequently, there is a substantial reduction in the

stiffness of the overall element. The collapsing means may be a small projection placed past the outlet orifice, which causes the vane to collapse or, more preferably, may be the reduction in size of the housing, reducing the distance between the internal wall of the housing and the axis of the rotor. The reduced clearance applies an interference in a direction opposed to the applied force causing the vane to flatten. The resilient material from which the vane is made will then permit the vane to recover its shape on the drive side of the housing past the inlet orifice.

[0033] In a preferred embodiment of the invention, the vanes may be made from a very flexible material, for instance, silicone or polyurethane, or other such material that is resistant to pool chemicals and displays good pressure-sealing properties.

[0034] Said flexible vanes may be supported by rigid or extremely stiff elements, which support the vane for a portion of its length, preferably 50 to 75 per cent. In order to resist the applied force, the vanes, possibly in combination with the support elements, may have means for selective stiffness.

[0035] Preferably such means for selective stiffness may be an arrangement changing the shape of the flexible vane so that when a pressure differential is developed, the flexible vanes form a shape having greater stiffness. On the return portion of the chamber, the flexible vanes may collapse onto the flat face when contact is made with the internal wall of the housing and so maintain a seal with the housing.

[0036] In a more preferred embodiment, the means to selectively stiffen the flexible vanes may be provided by the support elements, which are capable of transmitting the pressure differential to the flexible vane and drawing it into a shaped portion of the support element so that the flexible vane may selectively deform from a flat, low stiffness shape to a higher stiffness curved shape. On release of the pressure differential at and beyond the outlet orifice, the flexible vane may resume the flat orientation and be readily collapsed on contact with the internal wall. In this embodiment, it follows that the scope to reduce the rotor assembly is dependent upon the size of the support elements but is almost

independent of the size of the flexible vanes. Therefore, in order to reduce the size of the rotor assembly, there may be a balance in designing the size of the support elements, the initial and increased stiffness of the flexible vanes, and the magnitude of the applied force determined by the magnitude of the negative static pressure.

[0037] BRIEF DESCRIPTION OF THE DRAWINGS

[0038] It will be convenient to further describe the present invention with respect to the accompanying drawings, which illustrate possible arrangements of the invention. Other arrangements of the invention are possible and consequently the particularity of the accompanying drawings is not to be understood as superseding the generality of the preceding description of the invention.

[0039] Figure 1 is a perspective view of the open sided rotor assembly according to the present invention;

[0040] Figure 2a is a schematic cross-sectional view of the vane of the rotor assembly of Figure 1;

[0041] Figure 2b is a further schematic cross-sectional view of the vane of the rotor assembly according to Figure 1.

[0042] DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0043] Figure 1 shows a rotor assembly 1 according to the present invention. The rotor assembly 1 is one part of a self-propelled pool cleaner. The rotor assembly 1 is that portion of the pool cleaner into which is drawn the inlet water flow 6 through the inlet orifice 7, said inlet water flow 6 eventually passing through hose and pipework through the pool filter and returned to the swimming pool.

[0044] The rotor assembly 1 is used not only to draw in the inlet water flow 6 but to provide energy to the movement mechanism to propel the pool cleaner about the swimming pool and serve its primary function. In this case the rotor assembly 1 of the present invention comprises a housing 2 and a rotor 3 within

the housing, said rotor 3 comprising a plurality of flexible vanes 4 and rigid vane supports 5.

[0045] The rotor assembly 1 draws the inlet water flow 6 into the housing 2 via inlet orifice 7 and finally expels the outlet water flow 8 through the outlet orifice 9 either to another part of the pool cleaner or directly into the hose arrangement and directs the water flow 8 to the pool filter.

[0046] The flow of water though the housing 2 divides the housing into a drive portion 14 between the inlet 7 and outlet 9 and a return portion 15 of the housing 2 from the outlet 9 to the inlet 7. Thus, whilst in use, the housing 2 is completely immersed, the majority of flow in the housing is on the drive portion 14 with the return portion having a markedly reduced flow of water.

[0047] The rotor assembly 1 of the present invention is differentiated from a rotor assembly for a turbine type pool cleaner in that the vanes 4, being of a flexible nature, provide a pressure seal 10 between adjacent spaces 11 and 12. The pool pump functions by providing a negative static pressure at the outlet 9 of the housing 2 creating a negative static pressure within space 12. The inlet orifice 7 is sized so that the velocity head of the inlet water flow 6 is small and the static pressure in space 11 is not dissimilar to that of the external static pressure within the swimming pool. Consequently, a pressure differential between space 12 and space 11 creates an applied force pushing the vane 4 towards the outlet 9 and rotating the rotor 3 in a preferred direction. The pressure seal 10 ensures the rotor undergoes work, being the product of the applied static pressure force and the distance through which the rotor is moved and this energy converted to mechanical energy to the mechanism driving the propulsion system for the pool cleaner.

[0048] To ensure the pressure sealing between the adjacent spaces 11 and 12, the flexible vane 4 must act as a relatively soft seal against the internal wall of the housing. Materials such as silicone and polyurethane are ideal for such an application. However, said materials are known to provide little stiffness and unsupported such a flexible vane 4 could not resist the applied static pressure force used to drive the rotor 3. Vane supports 5 are incorporated with each

flexible vane 4 being supported by a vane support. The vane supports preferably 50 to 75 per cent of the length of the flexible vane 4 providing sufficient extension beyond the vane support 5 to form a seal with the internal wall of the housing.

[0049] The rotor assembly 1 of the present invention further features a housing 2 having a reduced size on the return portion 15 as compared to the drive portion 14 and so reducing the overall size of the pool cleaner. In order to achieve this reduction in size, the unsupported length of the flexible vane 4 is maximized so that when the flexible vane 16 reaches the return portion of the housing 15, it is collapsible into a defined position rotor return face 17 and the required clearance for the drive portion 14 is not required for the return portion 15. In order to minimize the size of the housing 2, the unsupported length of the flexible vane 4 must be maximized. However, because of its flexible nature, if the unsupported length of the flexible vane 4 is too long, the applied static pressure force will buckle the flexible vane 4 and so break the pressure seal 10 and consequently briefly lead to a reduction in power and efficiency of the rotor assembly 1. A further feature of the rotor assembly 1 according to the present invention is the ability of the rotor 3 to selectively stiffen the flexible vane 4 in the drive portion 14.

[0050] Firstly, the vane support 5 has pressure leakage holes 13, which permit the applied static force to be applied to the full length of the flexible vane 4 instead of just the unsupported length. This has the advantage of removing the upper peripheral edge of the support vane 5 from acting as a point of rotation for the unsupported length of the flexible vane 4. Secondly, the face of the vane support 5 adjacent to the flexible vane 4 is shaped such that as the flexible vane 4 is pressed into the vane support 5 under the applied static pressure force, the flexible vane 4 is resiliently deformed into a curved shape. Consequently, whilst a pressure difference exists between the adjacent spaces 11 and 12, the flexible vane 4 adopts the higher stiffness curved shape and on rotation of the rotor 3, when the pressure difference is equalised adjacent the outlet 9, the flexible vane

4 resiliently reforms a flat shape ready for collapsing into flexible vane 16 on the return portion of the housing.

[0051] The degree to which the selective stiffness of the flexible vane 4 enhances the resistance against the applied static pressure force is illustrated by figures 2a and 2b. Stiffness is directly proportional to the product of the secant modulus (Es) and the moment of inertia (I). The secant modulus is a function of the material properties and the moment of inertia is a function of the shape of the object under consideration. Figure 2a shows the undeformed cross-sectional shape of the flexible vane 4 of nominal width (B) and depth (D). The neutral (N. A.) axis about which the flexible vane 4 may bend is used to determine the moment of inertia (I) of the cross-sectional shape. In this case, a notional relationship between the dimensions are suggested as the width (B) being twenty times that of the depth (D) giving a moment of inertia equal to 1.67 D4.

[0052] Figure 2b shows the deformed shape of the flexible vane 4 should the deformed shape be a half circle. Using the same relationship between width (B) and depth (D), the moment of inertia of the deformed shape becomes 2,388 D4.

[0053] For a constant secant modulus between the deformed and undeformed shape, it can be shown for this example that the selective stiffness of the flexible vane 4 is enhanced on being deformed from a flat strip. It follows that for a range of similar parameters, the person skilled in the art can determine the required stiffness enhancement for the applied static pressure force and determine the material properties, flexible vane size and deformed shape required to resist the applied static pressure force.

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